NRC FORM 618
(8-2000)
10 CFR 71

U.S. NUCLEAR REGULATORY COMMISSION

CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE	PAGES
9309	7	71-9309	USA/9309/B(U)F-96	1 OF	8

2. PREAMBLE

a. This certificate is issued to certify that the package (packaging and contents) described in Item 5 below meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Material."

b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION.

a. ISSUED TO (*Name and Address*)

Global Nuclear Fuel - Americas, LLC
P.O. Box 780
Wilmington, NC 28402

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

Global Nuclear Fuel - Americas, LLC application dated March 31, 2004, as supplemented.

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: RAJ-II

(2) Description

The RAJ-II package is a rectangular box that is 742 mm (29.21 in) high by 720 mm (28.35 in) wide by 5,068 mm (199.53 in) long to transport a maximum of two Boiling Water Reactor (BWR) fuel assemblies or individual rods that meet the ASTM C996-96 standard of enriched commercial grade uranium, enriched reprocessed uranium, uranium oxide generic pressurized water reactor (PWR) or uranium carbide loose fuel rods in a 5 inch diameter stainless steel pipe.

It is comprised of one inner container and one outer container both made of stainless steel. The inner container is comprised of a double-wall stainless steel sheet structure with alumina silicate thermal insulator filling the gap between the two walls to reduce the flow of the heat into the contents in the event of a fire. Foam polyethylene cushioning material is placed on the inside of the inner container for protection of the fuel assembly. The outer container is comprised of a stainless steel angular framework covered with stainless steel plates. Inner container clamps are installed inside the outer container with a vibro-isolating device between to alleviate vibration occurring during transportation. Wood and honeycomb resin impregnated kraft paper are placed as shock absorbers to reduce shock in the event of a drop of the package. The fuel rod clad and ceramic nature of the fuel pellets provide primary containment of the radioactive material.

5.(a)(2) continued

The approximate dimensions and weights of the package are as follows

Maximum gross shipping weight	1,614 kg (3,558 lbs)
Maximum weight of inner container	308 kg (679 lbs)
Maximum weight of outer container	622 kg (1,371 lbs)
Maximum weight of packaging	930 kg (2,050 lbs)
Dimensions of inner container	
Length	4,686 mm (184.49 in)
Width	459 mm (18.07 in)
Height	286 mm (11.26 in)
Dimensions of outer container	
Length	5,068 mm (199.53 in)
Width	720 mm (28.35 in)
Height	742 mm (29.21 in)

(3) Drawings

This packaging is constructed in accordance with the Global Nuclear Fuel (GNF) Drawing Nos.

Outer Container Drawings	Inner Container Drawings	Contents Containers
105E3737, Rev. 6	105E3745, Rev. 8	105E3773, Rev. 1
105E3738, Rev. 7	105E3746, Rev. 1	0028B98, Rev. 1
105E3739, Rev. 4	105E3747, Rev. 4	
105E3740, Rev. 4	105E3748, Rev. 2	
105E3741, Rev. 1	105E3749, Rev. 6	
105E3742, Rev. 3		
105E3743, Rev. 4		
105E3744, Rev. 5		

5. continued

(b) Contents

(1) Type and form of material

Enriched commercial grade uranium or enriched reprocessed uranium, as defined in ASTM C996-96, uranium oxide or uranium carbide fuel rods enriched to no more than 5.0 weight percent in the U-235 isotope with limits specified in Table 1 and Table 2 below

Table 1 Maximum weight of uranium dioxide pellets per fuel assembly

Type 8x8 fuel assembly	Type 9x9 fuel assembly	Type 10x10 fuel assembly
235 kg	240 kg	275 kg

Table 2: Maximum Authorized Concentrations

Isotope	Maximum content
U-232	2.00×10^{-9} g/gU
U-234	2.00×10^{-3} g/gU
U-235	5.00×10^{-2} g/gU
U-236	2.50×10^{-2} g/gU
Np-237	1.66×10^{-6} g/gU
Pu-238	6.20×10^{-11} g/gU
Pu-239	3.04×10^{-9} g/gU
Pu-240	3.04×10^{-9} g/gU
Gamma Emitters	5.18×10^{5} MeV - Bq/kgU

5.(b)(1) continued

(i) 8 x 8 fuel assemblies comprised of 60 to 64 rods in a square array with a maximum active fuel rod length of 381 cm. The maximum pellet diameter, minimum clad thickness, rod pitch, water rod specifications, and poison rod specification are in accordance with Table 3 below.

(ii) 9 x 9 fuel assemblies comprised of 72 to 81 rods in a square array with a maximum active fuel rod length of 381 cm. The maximum pellet diameter, minimum clad thickness, rod pitch, water rod specifications, and poison rod specification are in accordance with Table 3 below.

(iii) 10 x 10 fuel assemblies comprised of 91 to 100 rods in a square array with a maximum active fuel rod length of 385 cm. The maximum pellet diameter, minimum clad thickness, rod pitch, water rod specifications, and poison rod specification are in accordance with Table 3 below.

(iv) Oxide fuel rods configured loose, in a 5 inch diameter schedule 40 stainless steel pipe/protective case or strapped together. When fuel rods are placed in polyethylene sleeves, each polyethylene sleeve shall not exceed 0.0152 cm in thickness. The maximum pellet diameter, minimum clad thickness, and rod specifications are in accordance with Table 4 below.

(v) Uranium carbide or generic PWR uranium oxide fuel rods configured loose, in a 5 inch diameter schedule 40 stainless steel pipe. When fuel rods are placed in polyethylene sleeves, each polyethylene sleeve shall not exceed 0.0152 cm in thickness. The maximum pellet diameter, minimum clad thickness, and rod specifications are in accordance with Table 4 below.

5.(b)(1) continued

Table 3: Fuel Assembly Parameters

Parameter	Units	Type	Type	Type	Type
Fuel Assembly Type	Rods	8x8	9x9	FANP 10x10	GNF 10x10
UO_2 Density		≤98% Theoretical	≤98% Theoretical	≤98% Theoretical	≤98% Theoretical
Number of water rods (See Condition 5.)	#	0, 2x2	0, 2-2x2 off-center diagonal, 3x3	0, 2-2x2 off-center diagonal, 3x3	0, 2-2x2 off-center diagonal, 3x3
Number of fuel rods	#	60 - 64	72 - 81	91 - 100	91 - 100
Fuel Rod OD	cm	≥1.176	≥1.093	≥1.000	≥1.010
Fuel Pellet OD	cm	≤1.05	≤0.96	≤0.895	≤0.895
Cladding Type		Zirconium Alloy	Zirconium Alloy	Zirconium Alloy	Zirconium Alloy
Cladding ID	cm	≤1.10	≤1.02	≤0.933	≤0.934
Cladding Thickness	cm	≥0.038	≥0.036	≥0.033	≥0.038
Active fuel length	cm	≤381	≤381	≤385	≤385
Fuel Rod Pitch	cm	≤1.692	≤1.51	≤1.350	≤1.350
U-235 Pellet Enrichment	wt%	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
Maximum Lattice Average Enrichment	wt%	≤ 5.0	≤ 5.0	≤ 5.0	≤ 5.0
Channel Thickness[a]	cm	0.17 - 0.3048	0.17 - 0.3048	0.17 - 0.3048	0.17 - 0.3048
Partial Length Fuel Rods (1/3 through 2/3 normal length)	Max #	None	12	14	14
Gadolinia Requirements	#				
Lattice Average Enrichment[b]					
≤ 5.0 wt % U-235	@ wt% Gd_2O_3	7 @ 2 wt %	10 @ 2 wt %	12 @ 2 wt %	12 @ 2 wt %
≤ 4.7 wt % U-235		6 @ 2 wt %	8 @ 2 wt %	12 @ 2 wt %	12 @ 2 wt %
≤ 4.6 wt % U-235		6 @ 2 wt %	8 @ 2 wt %	10 @ 2 wt %	10 @ 2 wt %
≤ 4.3 wt % U-235		6 @ 2 wt %	8 @ 2 wt %	9 @ 2 wt %	9 @ 2 wt %
≤ 4.2 wt % U-235		6 @ 2 wt %	6 @ 2 wt %	8 @ 2 wt %	8 @ 2 wt %
≤ 4.1 wt % U-235		4 @ 2 wt %	6 @ 2 wt %	8 @ 2 wt %	8 @ 2 wt %
≤ 3.9 wt % U-235		4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.8 wt % U-235		4 @ 2 wt %	4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.7 wt % U-235		2 @ 2 wt %	4 @ 2 wt %	6 @ 2 wt %	6 @ 2 wt %
≤ 3.6 wt % U-235		2 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %
≤ 3.5 wt % U-235		2 @ 2 wt %	2 @ 2 wt %	4 @ 2 wt %	4 @ 2 wt %
≤ 3.3 wt % U-235		2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %
≤ 3.1 wt % U-235		None	2 @ 2 wt %	2 @ 2 wt %	2 @ 2 wt %
≤ 3.0 wt % U-235		None	None	2 @ 2 wt %	2 @ 2 wt %
≤ 2.9 wt % U-235		None	None	None	None
Polyethylene Equivalent Mass (Maximum per Assembly)[c]	kg	11	11	10.2	10.2

a. Transport with or without channels is acceptable
b. Required gadolinia rods must be distributed symmetrically about the major diagonal
c. Polyethylene equivalent mass calculation (refer to 6.3.2.2 of the application)

5.(b)(1) continued

Table 4: Fuel Rod Parameters

Parameter	Units	Type					
Fuel Assembly Type		8x8 (UO2)	9x9 (UO2)	10x10 (UO2)	CANDU-14 (UO2)	CANDU-25 (UO2)	Generic PWR (UO2)
UO2 or MOX Fuel Density		98% theoretical	98% theoretical	98% theoretical	98% theoretical	98% theoretical	98% theoretical
Fuel rod OD	cm	≤1.10	≤1.02	≤1.00	≤1.340	≤0.996	≤1.118
Fuel Pellet OD	cm	≤1.05	≤0.96	≤0.90	≤1.254	≤0.950	≤0.98
Cladding Type		Zirc Alloy	Zirc Alloy	Zirc Alloy	Zirc Alloy or SS	Zirc Alloy or SS	Zirc Alloy or SS
Cladding ID	cm	≤1.10	≤1.02	≤1.00	≤1.267	≤0.951	≤1.004
Cladding Thickness	cm	≥0.038	≥0.036	≥0.038	≥0.033	≥0.033	≥0.033
Active fuel Length	cm	≤381	≤381	≤385	≤47.752	≤40.013	≤450
Maximum U-235 Pellet Enrichment	wt.%	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0
Maximum Average fuel rod Enrichment	wt.%	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0
Loose Rod Configuration							
Freely Loose		≤25	≤25	≤25	N/A	N/A	N/A
Packed in 5" SS Pipe or Protective Case [3]		≤22	≤26	≤30	≤74 [2]	≤130 [2]	≤105 [2]
Strapped Together		≤25	≤25	≤25	N/A	N/A	N/A

[1] Previous analysis (Ref. 1) based on most conservative loose rod configuration (i.e. no credit taken for 5" SS pipe)
[2] Including partial rods (in reality, apply dense packing of congruent rods in the pipe) and only in 5" SS pipes
[3] Protective case consists of SS box with lid

5.(b)(2) Maximum quantity of material per package

Total weight of payload contents (fuel assemblies, or fuel rods and rod shipping containers) not to exceed 684 kg (1508 pounds).

(i) For the contents described in 5(b)(1)(i), 5(b)(1)(ii), and 5(b)(1)(iii) two fuel assemblies

(ii) For the contents described in 5(b)(1)(iv) and 5(b)(1)(v) allowable number of fuel rods per compartment (2 compartments per package)

(c) Criticality Safety Index, except for contents described in 5(b)(1)(v) and limited in 5(b)(2)(ii) 1 0

Criticality Safety Index for contents described in 5(b)(1)(v) and limited in 5(b)(2)(ii) 2 1

6. In addition to the requirements of Subpart G of 10 CFR Part 71:

(a) The package shall be prepared for shipment and operated in accordance with the Package Operations of Chapter 7 of the application, as supplemented.

(b) The packaging must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application, as supplemented.

(c) Prior to each shipment, the stainless steel components of the packaging must be visually inspected. Packages in which stainless steel components show pitting corrosion, cracking, or pinholes are not authorized for transport.

(d) If wrapping is used on the unirradiated fuel assemblies, the ends must be assured to be open during the shipment in the package.

7. Cluster separators are optional and may be comprised of polyethylene or other plastics. Polyethylene or plastic mass limits shall be determined in accordance with Section 6.3.2.2 (Material Specifications) of the application, as supplemented.

8. Water rods are limited as shown in Table 3 above.

For 8 x 8 fuel assembly designs, there can be either 0 or 1 water rod, and the water rod location occupies a space equivalent to 2 x 2 fuel rods. This is designated as 0, 2 x 2 in the table.

For 9 x 9 and 10 x 10 fuel assembly designs, there can be either 0, 1, or 2 water rods in the assembly, and the water rod location occupies a space equivalent to (a) two 2 x 2 fuel rod equivalent spaces on a diagonal at the center of the assembly, or (b) one 3 x 3 fuel rod equivalent

space (9 fuel rods space) in the center of the assembly. These configurations are designated as 0, 2 - 2x2 off-center diagonal, 3x3 in the table

9. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.17.

10 Transport by air of fissile material is not authorized

11 Revision No 6 of this certificate may be used until May 31, 2009

12 Expiration date November 30 2009

REFERENCES

Global Nuclear Fuel - Americas, LLC, application dated March 31, 2004.

Supplement dated: April 22, September 3, September 16, October 28, November 8 and 29, 2004; and April 8, May 25, June 6, August 3, 2005; and January 27, 2006; and February 16 and April 21, 2006; and June 12, July 11, November 8, 2007, February 29, March 14, and March 20, 2008.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

Meraj Rahimi, Acting Chief
Licensing Branch
Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety
and Safeguards

Date: May 28, 2008

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT

Docket No. 71-9309
Model No. RAJ-II
Certificate of Compliance No. 9309
Revision No. 7

SUMMARY

By application dated June 12, 2007, and as supplemented by letters dated July 11, 2007, November 8, 2007, February 29, 2008, March 14, 2008, and March 20, 2008, Global Nuclear Fuel – Americas, LLC (GNF or the applicant) requested an amendment to Certificate of Compliance (CoC) No 9309, for the Model No RAJ-II package The applicant requested that Condition 5(b), Contents, be revised to include either loose uranium carbide (UC) or PWR uranium-oxide (UO_2) fuel rods in a 5-inch stainless steel pipe container

The staff reviewed this request in accordance with the guidance provided in NUREG-1609, "Standard Review Plan for Transportation Packages for Radioactive Materials." The staff determined based on its review, the requested change does not affect the ability of the Model No. RAJ-II package of meeting the requirements of 10 CFR Part 71.

EVALUATION

By application dated June 12, 2007, and as supplemented, GNF requested that CoC No. 9309 for the Model No. RAJ-II package be revised to include either loose UC or PWR UO_2 fuel rods in a 5-inch stainless steel pipe container. This application included Revisions 5 and 6 of the GNF RAJ-II package Safety Analysis Report (SAR).

In Section 6.1.3 of the SAR, the applicant provided criticality safety index (CSI) calculations for the various contents that the Model No. RAJ-II packaging is designed to transport. The application included results of CSI calculations for two different package loading configurations, (8x1x8 and 4x2x6 arrays) for either the loose UC or UO_2 fuel rod in 5-inch stainless steel pipe containers. The CSI calculation results were 1.6 and 2.1 for these two package arrays respectively. Therefore, a CSI of 2.1 shall be used for when the contents consist of either loose UC or PWR UO_2 fuel rods in a 5-inch stainless steel pipe container. This is the more limiting for this type of content.

In Section 6.3.3 of the SAR, the applicant described the GEMER computer code. This code was used to perform criticality safety evaluations for the Model No. RAJ-II package with contents of either loose UC or PWR UO_2 rods in 5-inch stainless steel pipe containers. The GEMER code is a Monte Carlo method based criticality analysis computer code that uses continuous energy library with explicit treatment of resolved resonance cross sections. The cross sections used in GEMER are obtained by collapsing the ENDF/B-IV into 190 groups. The cross sections in the resonance ranges are converted into resonance parameters of resonance kernels. The resonance cross sections in the Monte Carlo sampling are computed from the resonance kernels rather than from the broad group cross sections.

In Section 6.10.2 of the SAR, the applicant performed code bias analyses for the GEMER code. The GEMER code was validated against experiments that have uranium form, chemical composition, and moderator/reflection conditions similar to those of the application. For low-enriched UO_2 lattice systems without poison, the calculational bias and bias uncertainty of GEMER code were provided in Reference No. 13 of the SAR.

In order to demonstrate that ENDF/B-IV data could be used for criticality evaluations and have results with acceptable accuracy for this specific application, the applicant provided a comparison of the k_{eff} values calculated with the MCNP5 code using the ENDF/B-VII cross section library and the k_{eff} values calculated with the GEMER code using the ENDF/B-IV cross section library for eight benchmark experiments from the "International Handbook of Evaluated Criticality Safety Benchmark Experiments." The results show that the GEMER code produces a systematic under-prediction of the k_{eff}. A larger bias of -0.0132 was used in calculation of the k_{safe} value for a larger criticality safety margin

In addition, the applicant provided details of its evaluation of the loose rod package and the Area of Applicability (AOA) for the benchmark experiments in Reference No. 13 of the SAR. The applicant explained in Reference No. 13 that the criticality model uses a free gas model for the UC fuel and an extra safety margin of 0.01 was added to account for unknown uncertainty because of lack of benchmark experiment data. The staff has determined based on the information presented in Reference No. 13 and the additional details provided by the applicant about the AOA for uranium carbide (UC) fuel. The staff concluded that benchmarks are valid and using free gas model for the UC fuel is acceptable.

The maximum U-235 enrichment of either a loose UC or PWR UO_2 fuel rod is 5%. The table below provides the maximum number of fuel rods per the 5-inch stainless steel pipe for different fuel types.

Maximum allowable numbers of fuel rods per 5-inch SS pipe in the RAJ-II package

Fuel Name	Fuel Assembly Size	Maximum Number of Fuel Rods Per 5-inch Pipe
GNF	10 X 10	30
GNF	9 X 9	26
GNF	8 X 8	22

Based on the applicant's analysis packages with the 8x8 GNF type fuel assembly exhibited the maximum k_{eff} peak in criticality versus fuel pin pitch. The results of the applicant's evaluation of the UC and UO_2 PWR rods in the 5-inch stainless steel pipe containers demonstrated that the above limits are also applicable to these new fuel types. The parameters for UC rods are the CANDU-14, CANDU-25, CANDU UC fuels, and the generic UO_2 PWR rods as listed in Table 6-2 of the SAR. Also, the applicant evaluated 8x1x8 and 6x2x4 arrays of packages of the UC and UO_2 PWR rods in the 5-inch stainless steel pipe containers assumed damaged and flooded with water. The results of the applicant's evaluation showed that the maximum k_{eff} ($k_{eff} + 2\sigma$) is 0.91310 for the 8x1x8 array and 0.83505 for the 6x2x4 array for the CANDU-25 (UC) rod packages.

The staff has evaluated GNF's amendment request and performed confirmatory analyses of the various package loading configurations. Based on this evaluation the staff determined that GNF has demonstrated that the Model No. RAJ-II package would continue to meet the criticality

safety requirements of 10 CFR Part 71 with contents of either loose UC or PWR UO_2 rods in 5-inch stainless steel pipe containers.

CONCLUSION

CoC No. 9309 has been revised as follows:

1 Condition 5.(b)(1), Table 4 was revised to include loose UC or PWR UO_2 rods in 5-inch stainless steel pipe containers as approved contents.

Table 4: Fuel Rod Parameters

Parameter	Units	Type					
Fuel Assembly Type		14X14 (UO2)	15X15 (UO2)	17X17 (UO2)	CANDU-37 (UO2)	CANDU-28 (UO2)	Generic PWR (UO2)
UO2 or UC Fuel Density		98% theoretical	98% theoretical	98% theoretical	98% theoretical	98% theoretical	98% theoretical
Fuel rod OD	cm	≤1.140	≤1.102	≤1.100	≤1.340	≤0.996	≤1.118
Fuel Pellet OD	cm	≤1.105	≤0.96	≤0.90	≤1.254	≤0.950	≤0.98
Cladding Type		Zirc Alloy	Zirc Alloy	Zirc Alloy	Zirc Alloy or SS	Zirc Alloy or SS	Zirc Alloy or SS
Cladding ID	cm	≤1.10	≤1.02	≤1.00	≤1.267	≤0.951	≤1.004
Cladding Thickness	cm	≥0.038	≥0.036	≥0.038	≥0.033	≥0.033	≥0.033
Active fuel Length	cm	≤381	≤381	≤385	≤47.752	≤40.013	≤450
Maximum U-235 Pellet Enrichment	wt.%	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0
Maximum Average fuel rod Enrichment	wt.%	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0	≤5.0
Loose Rod Configuration							
Freely Loose		≤25	≤25	≤25	N/A	N/A	N/A
Packed in 5" SS Pipe or Protective Case [3]		≤22	≤26	≤30	≤74 [2]	≤130 [2]	≤105 [2]
Strapped Together		≤25	≤25	≤25	N/A	N/A	N/A

[1] Previous analysis (Ref 1) based on most conservative loose rod configuration (i.e no credit taken for 5" SS pipe)
[2] Including partial rods (in reality, apply dense packing of congruent rods in the pipe) and only in 5" SS pipes
[3] Protective case consists of SS box with lid

2. Condition 5.(c) was revised to include a CSI for shipment of either loose UC or PWR UO_2 rods in 5-inch stainless steel pipe containers.

5.(c) Criticality Safety Index, except for contents described in 5(b)(1)(v) and limited in 5(b)(2)(ii) 1.0

Criticality Safety Index for contents described in 5(b)(1)(v) and limited in 5(b)(2)(ii) 2.1

These changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9309,
Revision No. 7, on May 28, 2008.